

# **“Nature’s Barter System”**

**by**

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**Permaculture Day**

**Bowen Island, BC**

**In the course of my investigation I discovered that ...**

**In the last 30 years there has been an amazing revolution in our understanding of soil biology and nature's complexity.**

**It's a good news story that can help us  
avoid the looming collapse of agriculture,  
reduce global warming,  
reduce chronic disease epidemics**

**These discoveries allow us to work with nature to restore soil health leading to:**

**healthier plants,**

**healthier food,**

**healthier people,**

**healthier planet**

**This way of growing is called Regenerative Agriculture.**

**Basically, it is about mimicking nature which is at  
the heart of permaculture.**

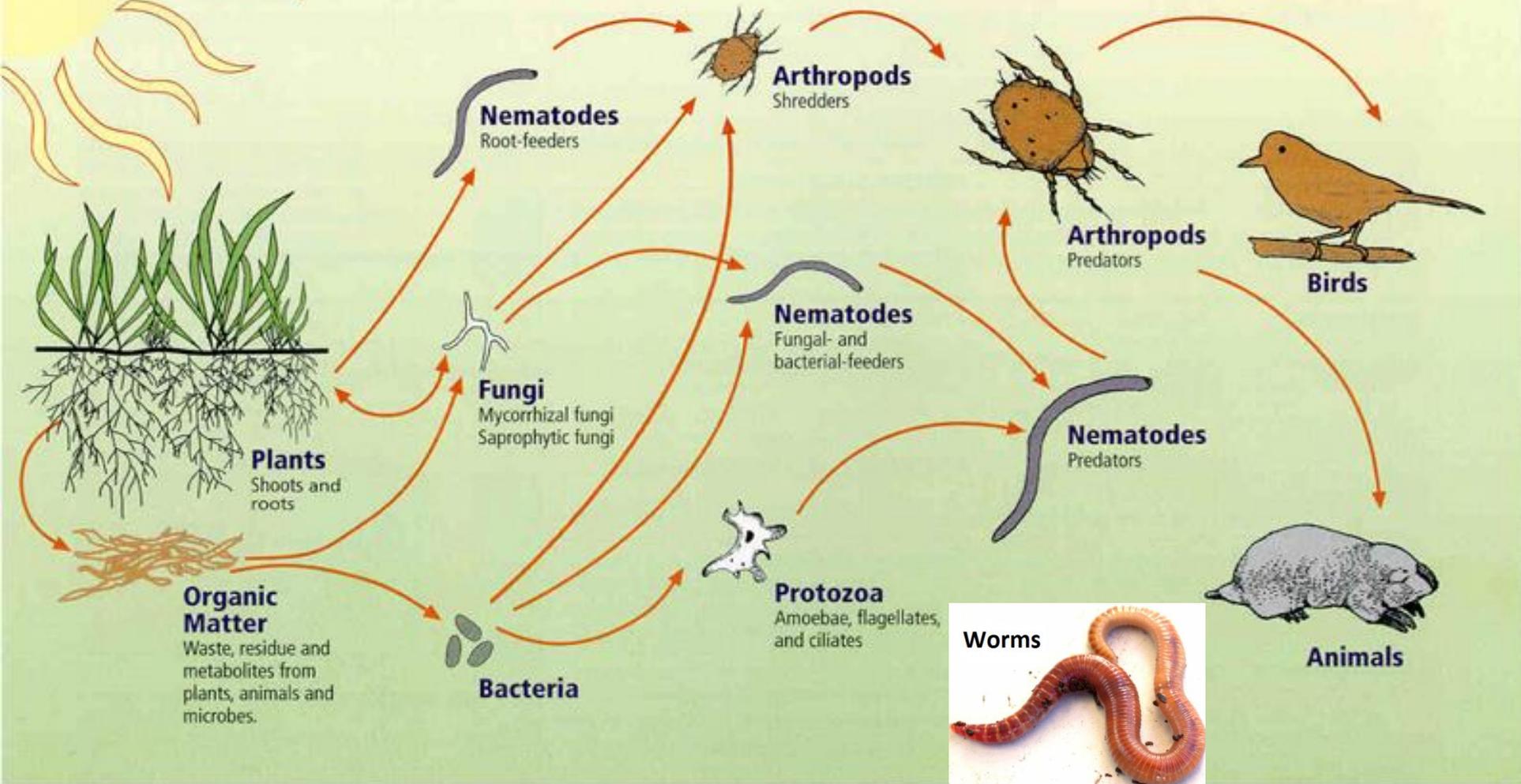
# Microbes are the secret behind healthy soil.

Each teaspoon of healthy soil contains as many microbes as the population of humans on earth.



# The Soil Food Web

Image courtesy of USDA Natural Resources Conservation Services  
<http://www.nrc.usda.gov/wps/portal/nrcs/main/soils/health/biology>

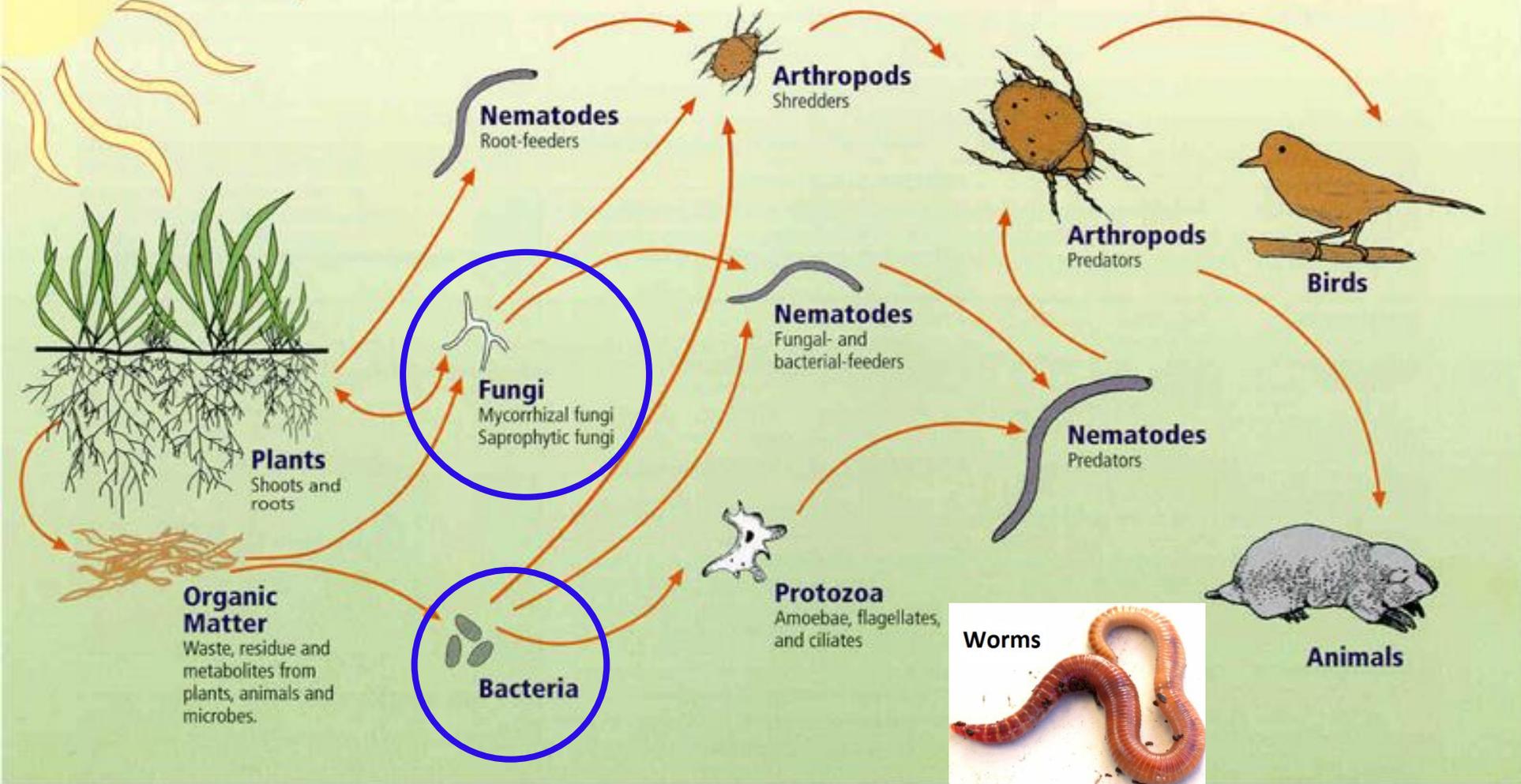


Here are some of the microscopic and visible actors in the soil food web

Understanding their roles is key to appreciating the new revolution in soil biology

# The Soil Food Web

Image courtesy of USDA Natural Resources Conservation Services  
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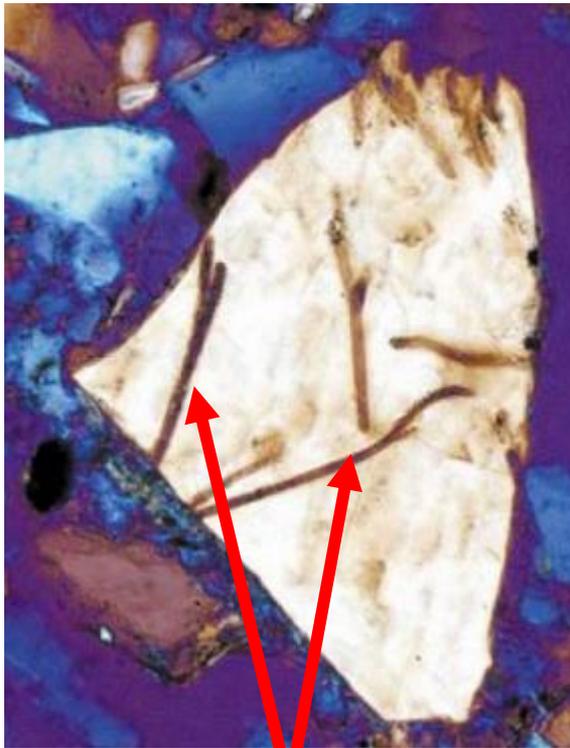
**Bacteria and fungi are at the base of this predator-prey relationship**

THE SCIENCES MIND HEALTH TECH SUSTAINABILITY EDUCATION VIDEO PODCASTS BLOGS STORE

<https://blogs.scientificamerican.com/artful-amoeba/the-world-s-largest-mining-operation-is-run-by-fungi/>

By Jenifer Fraser on November 5, 2015

# The World's Largest Mining Operation Is Run by Fungi



**Fungal mining tunnels**

**"Linking plants to rocks:  
ectomycorrhizal fungi  
mobilize nutrients from  
minerals."**

Thin-section micrograph of a tunneled feldspar.  
Box 4 I(c) from Renske Landeweert et al. *Trends  
in Ecology & Evolution* 16, no. 5 (2001): 248-  
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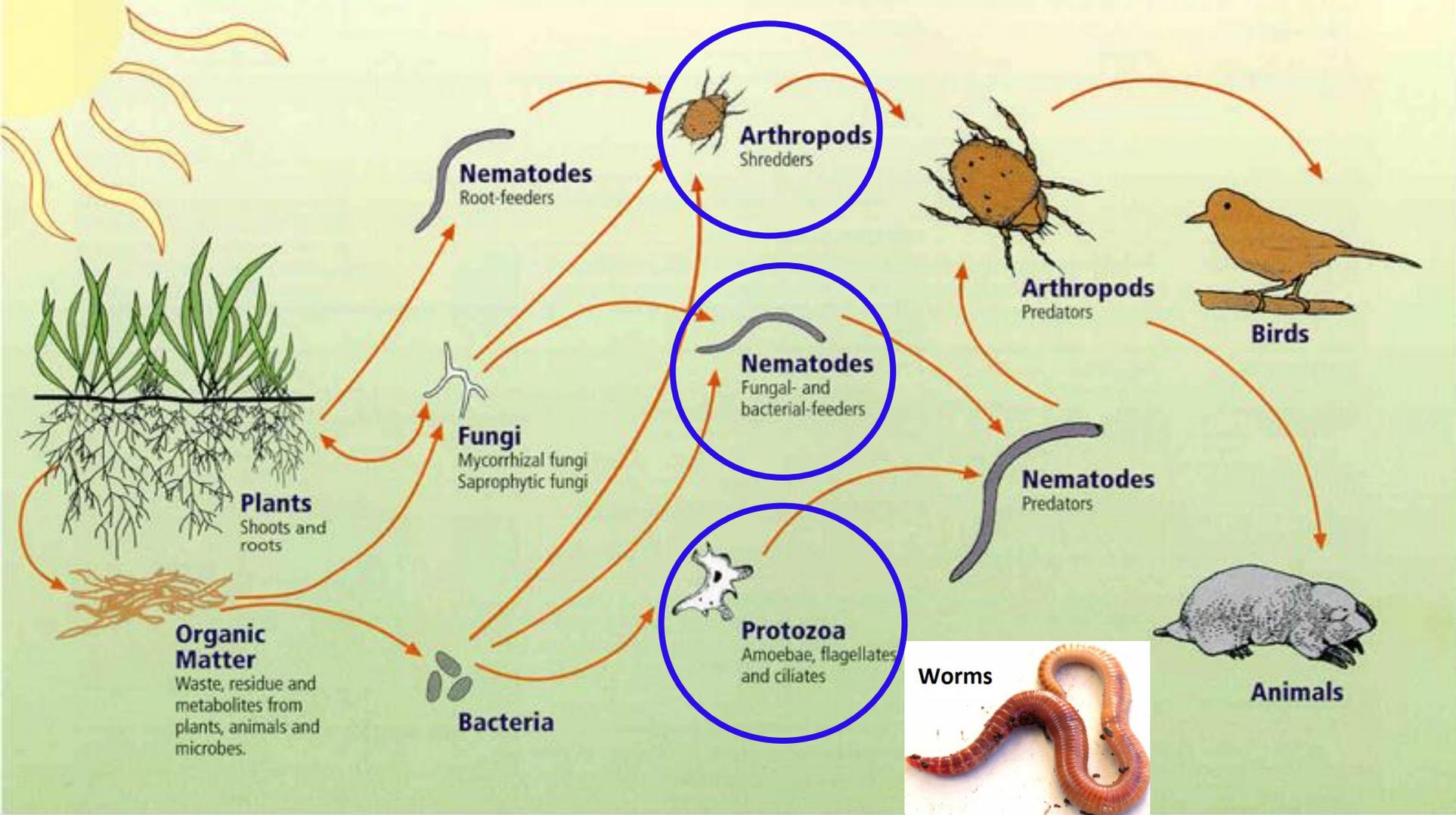
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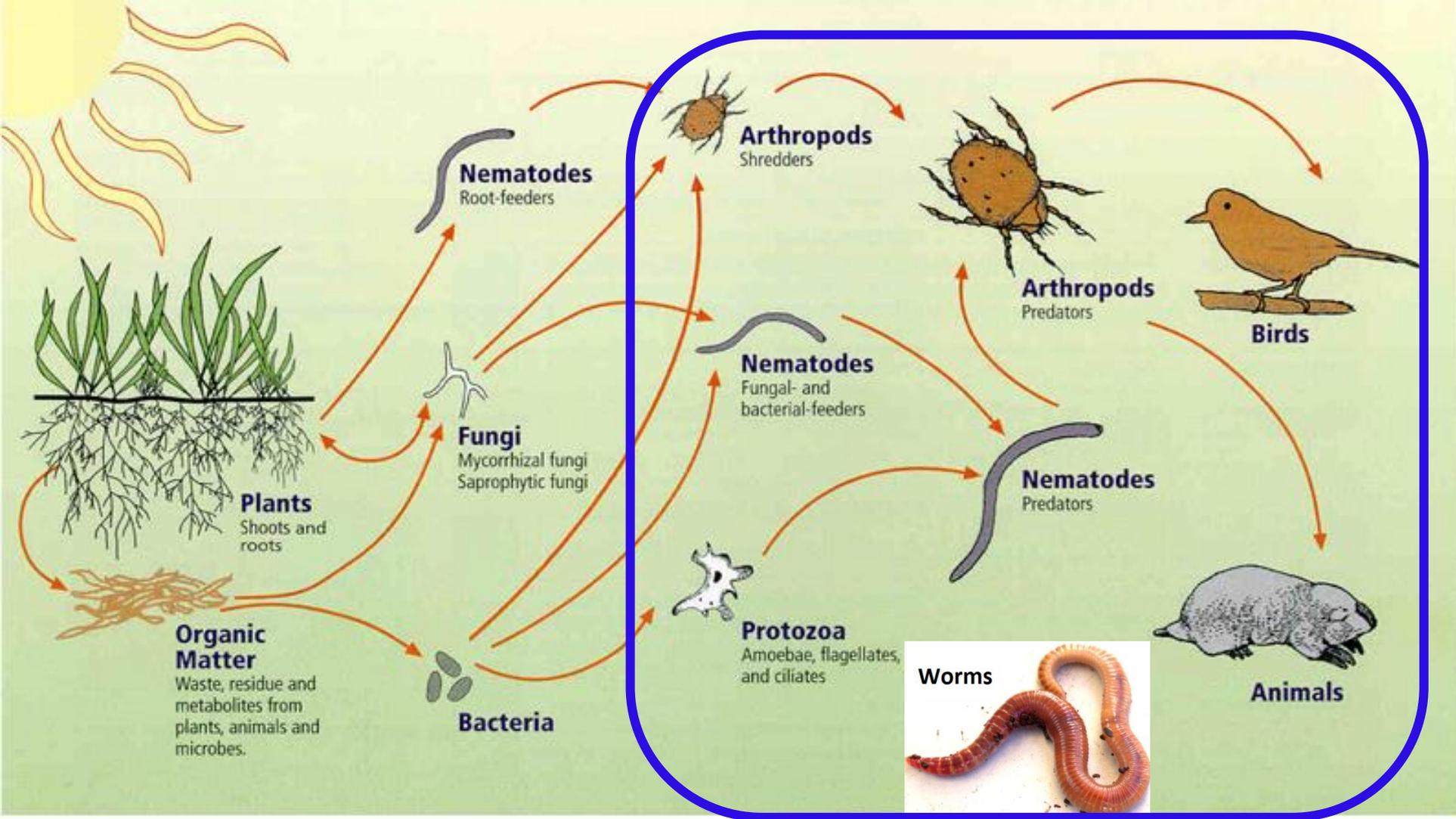
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**When we kill off the soil microbes with current agricultural practices,  
we shut down nature's mining operation and turn living soil into dirt.**

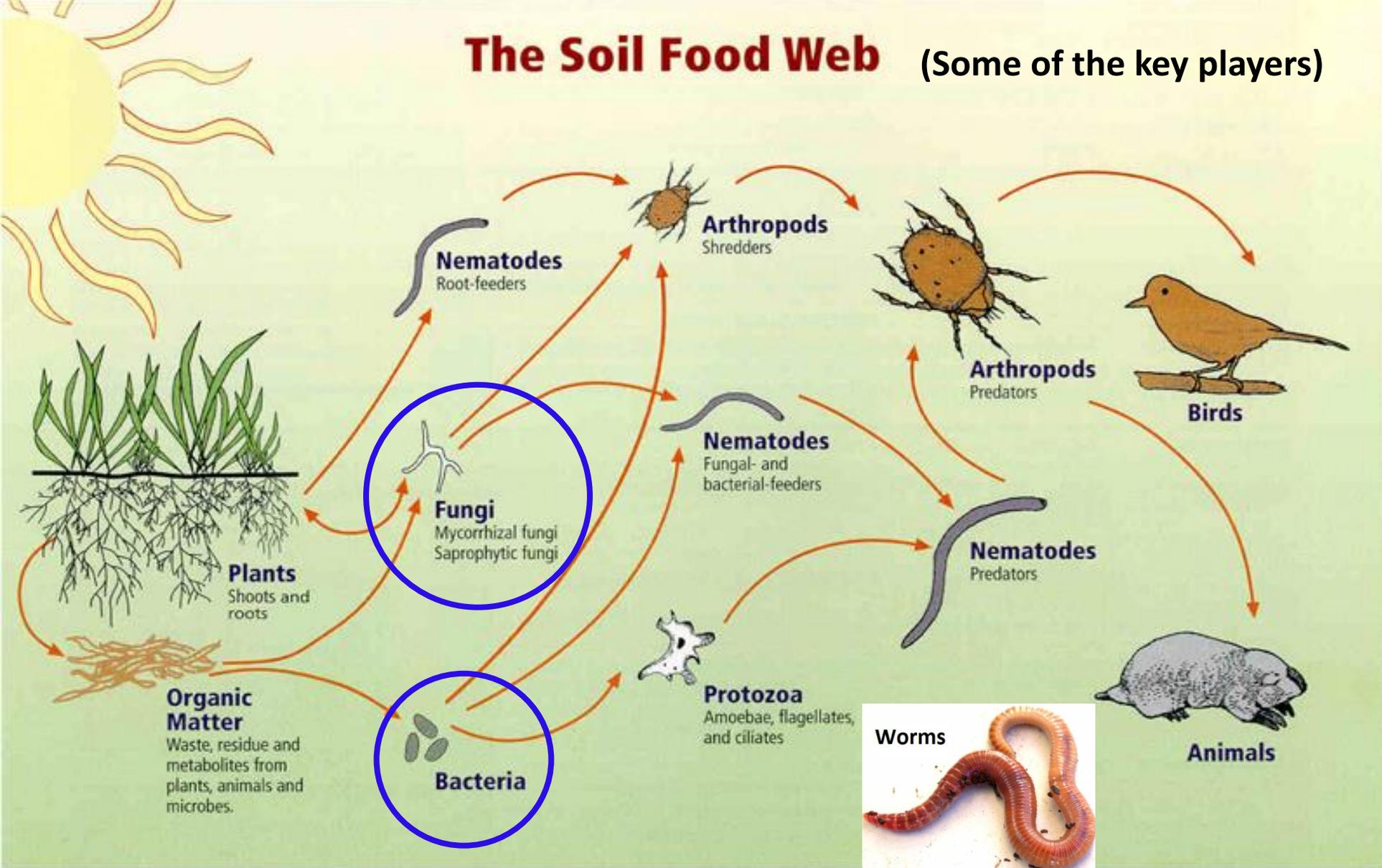


**The important role of the microscopic predators**



**We need a hierarchy of predators to preserve a stable balance of predators and prey.**

# The Soil Food Web (Some of the key players)



The bacteria and fungi are concentrated right next to the plant root because the plants attract and feed them

**Plants are the  
conductors of  
this symphony  
of nature**

**How do they do it?**



**Credit: Argan tree at Agadir by lgt 1400 CC BY SA 4.0**

**[https://commons.wikimedia.org/wiki/File:Argan\\_tree\\_@\\_Agadir.jpg](https://commons.wikimedia.org/wiki/File:Argan_tree_@_Agadir.jpg)**

# Plants are the conductors of this symphony of nature

Up to 40% of the sugars, carbohydrates and proteins that plants produce are released from their roots to attract and feed the microbes the plant requires.

Called root exudates.



Credit: Argan tree at Agadir by lgt 1400 CC BY SA 4.0

[https://commons.wikimedia.org/wiki/File:Argan\\_tree\\_@\\_Agadir.jpg](https://commons.wikimedia.org/wiki/File:Argan_tree_@_Agadir.jpg)

“What do you make when you mix sugar, a carbohydrate like flour, and protein like eggs and milk?”

That’s a recipe for cakes and cookies. So, according to Dr. Elaine Ingham plants are putting out cakes and cookies to attract the microbes.”



# Plants also release exudates through their foliage.

In healthy soil conditions leaf surfaces are covered by microbes held to the plant by the strong biotic glues. That protective layer is one of nature's way of achieving disease suppression.



# Bacteria and fungi build soil structure



Together they build underground cities for the microbes to live in.

Image credit UN FAO.

**microaggregate (too small to see by eye)**

Bacteria secrete biotic glues that stick soil minerals and organic matter together in what are called microaggregates.

Fungal strands (right) tie microaggregates together forming aggregates (2-5 mm)



Largest organism

# Soil Aggregates Formed Around Plant Roots



Dr. Christine Jones [https://www.youtube.com/watch?v=C3\\_w\\_Gp1mLM](https://www.youtube.com/watch?v=C3_w_Gp1mLM)

# What happens when we plow or dig the soil

Plowing slices and dices the soil structure built by bacteria and fungi with their biotic glues - turning living soil into dirt.



Credit: Aalang (CC BY-SA 3.0)

[https://commons.wikimedia.org/wiki/File:Plowing\\_ecomat.jpg](https://commons.wikimedia.org/wiki/File:Plowing_ecomat.jpg)

Credit: Trish Steel, (CC BY-SA 3.0)



[https://commons.wikimedia.org/wiki/File:Feeding\\_Frenzy,\\_Faulston\\_Farm\\_-\\_geograph.org.uk\\_-\\_702677.jpg](https://commons.wikimedia.org/wiki/File:Feeding_Frenzy,_Faulston_Farm_-_geograph.org.uk_-_702677.jpg)

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Credit: Aalang (CC BY-SA 3.0)

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Credit: Trish Steel, (CC BY-SA 3.0)



**Those underground cities were home to a diverse ecosystem capable of providing all the nutrients plants required without the need for chemical fertilizers.**

[https://commons.wikimedia.org/wiki/File:Feeding\\_Frenzy,\\_Faulston\\_Farm\\_-\\_geograph.org.uk\\_-\\_702677.jpg](https://commons.wikimedia.org/wiki/File:Feeding_Frenzy,_Faulston_Farm_-_geograph.org.uk_-_702677.jpg)

# What happens when we plow or dig the soil

About 20 years ago it was discovered that plowing releases additional soil carbon into the atmosphere as climate warming CO<sub>2</sub>



Credit: Aalang (CC BY-SA 3.0)

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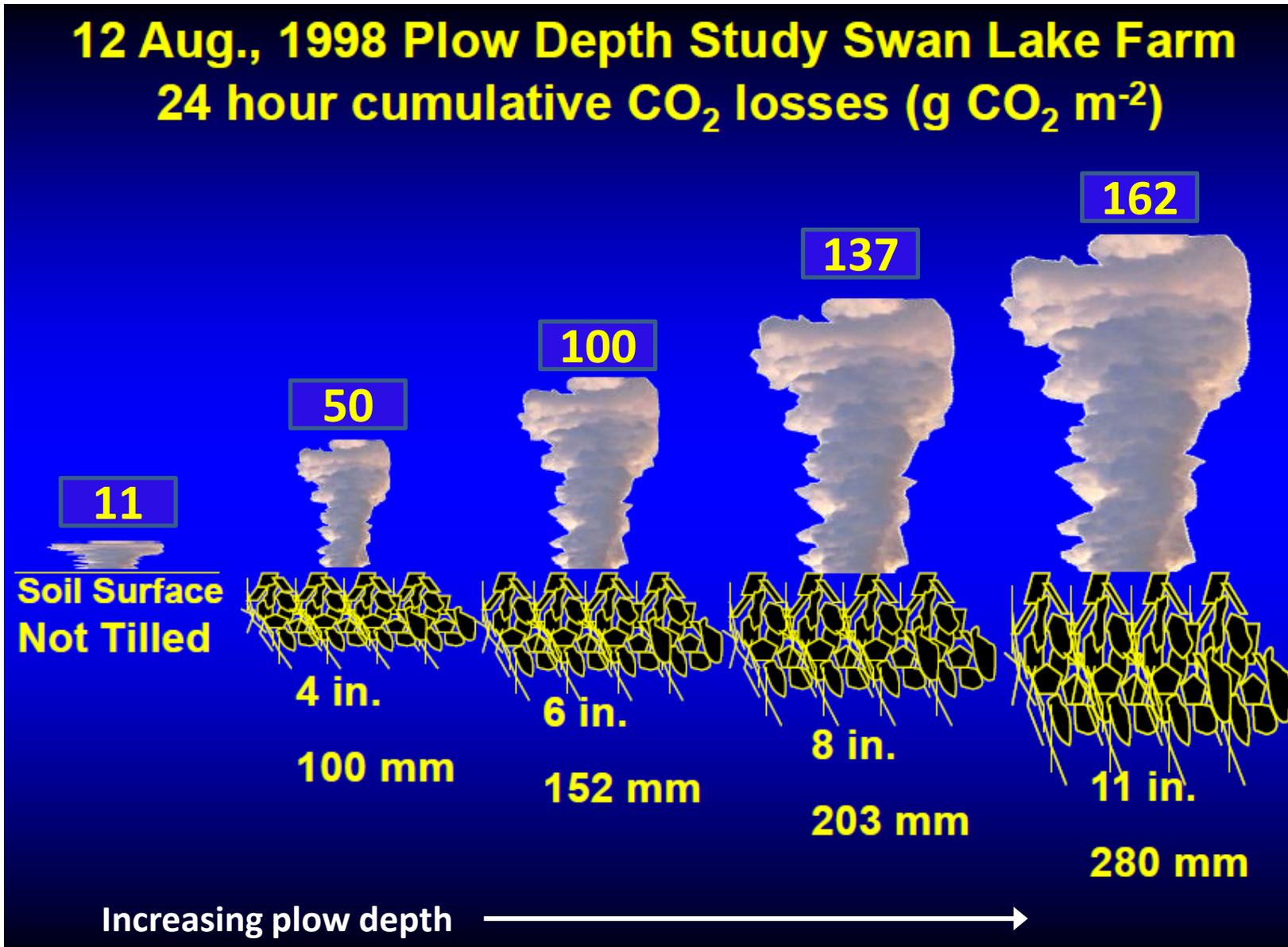
Credit: Trish Steel, (CC BY-SA 3.0)



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# Effect of tilling on CO<sub>2</sub> emission

Dr. Don Reicosky , USDA  
Agricultural Research Services



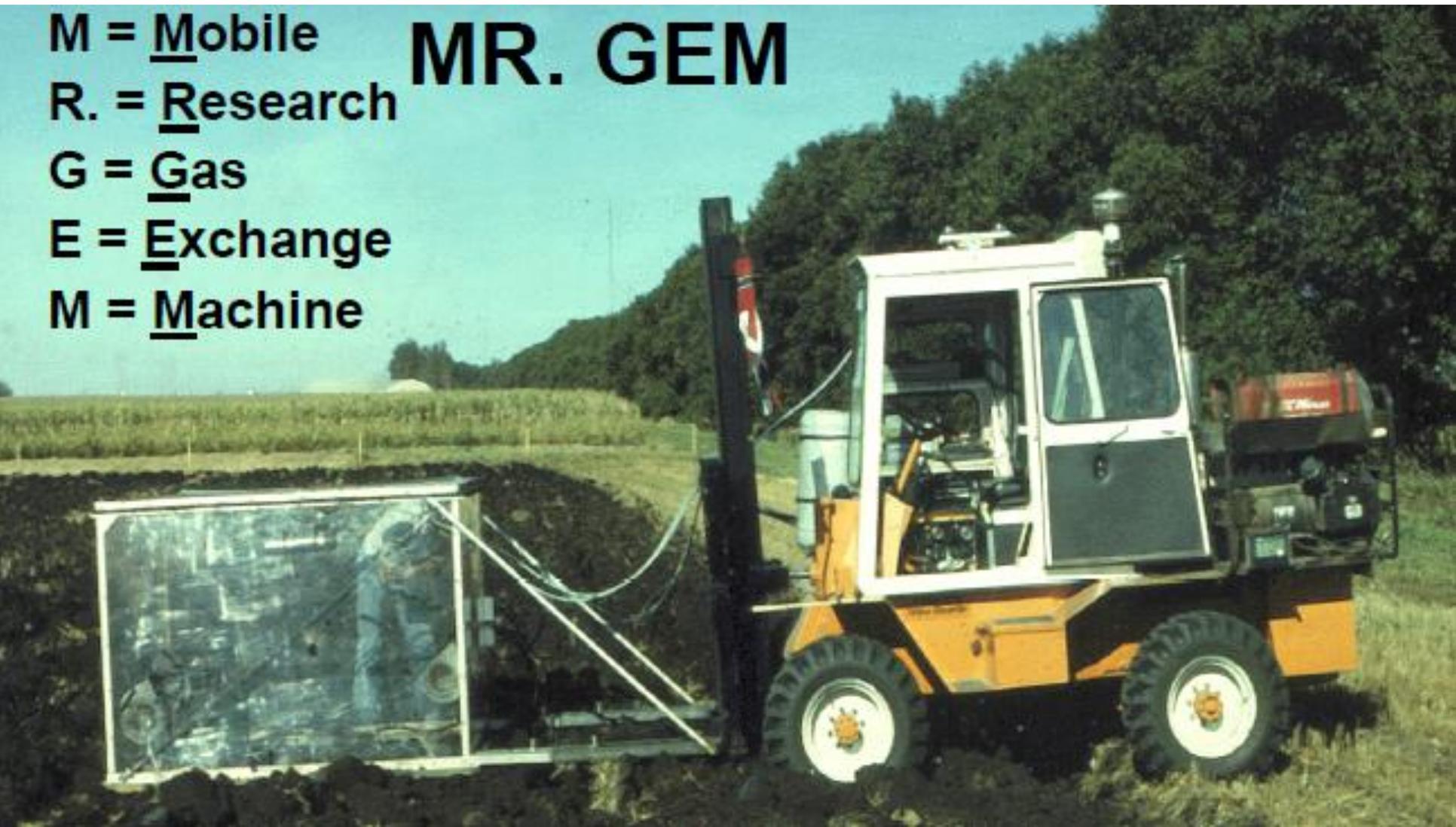
D.C. Reicosky and D. W. Archer, Soil and Tillage Research, Vol. 94, Issue 1, pp. 109–121, 2007  
Improved analysis allowing for weather-induced temporal variability

# Tillage and planting: impact on carbon and soil quality

Dr. Don Reicosky USDA-ARS

M = Mobile  
R. = Research  
G = Gas  
E = Exchange  
M = Machine

## MR. GEM



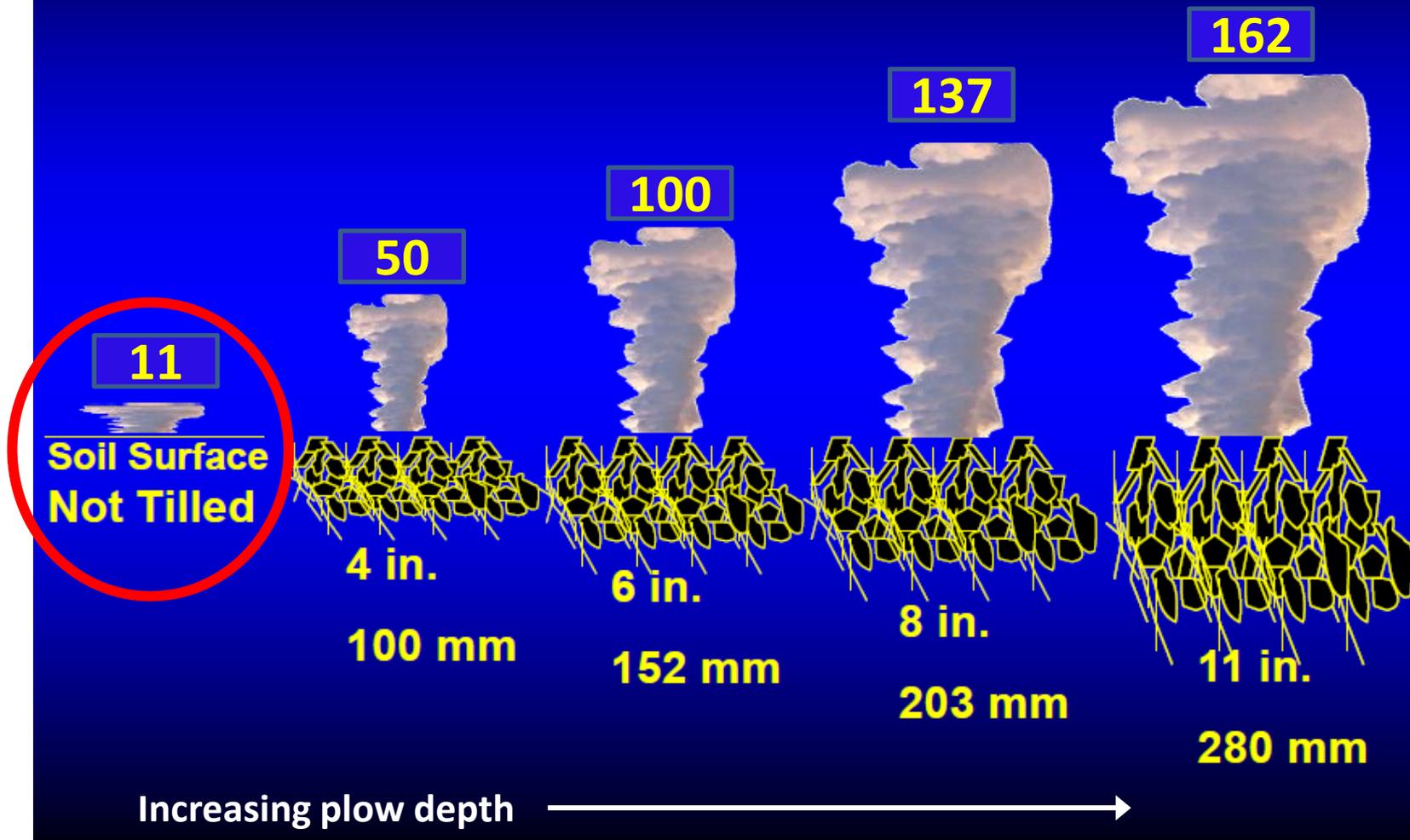
<http://www.fairfieldswcd.org/Attachments/Soil%20Quality.pdf>

1 min soil videos

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**12 Aug., 1998 Plow Depth Study Swan Lake Farm**  
**24 hour cumulative CO<sub>2</sub> losses (g CO<sub>2</sub> m<sup>-2</sup>)**

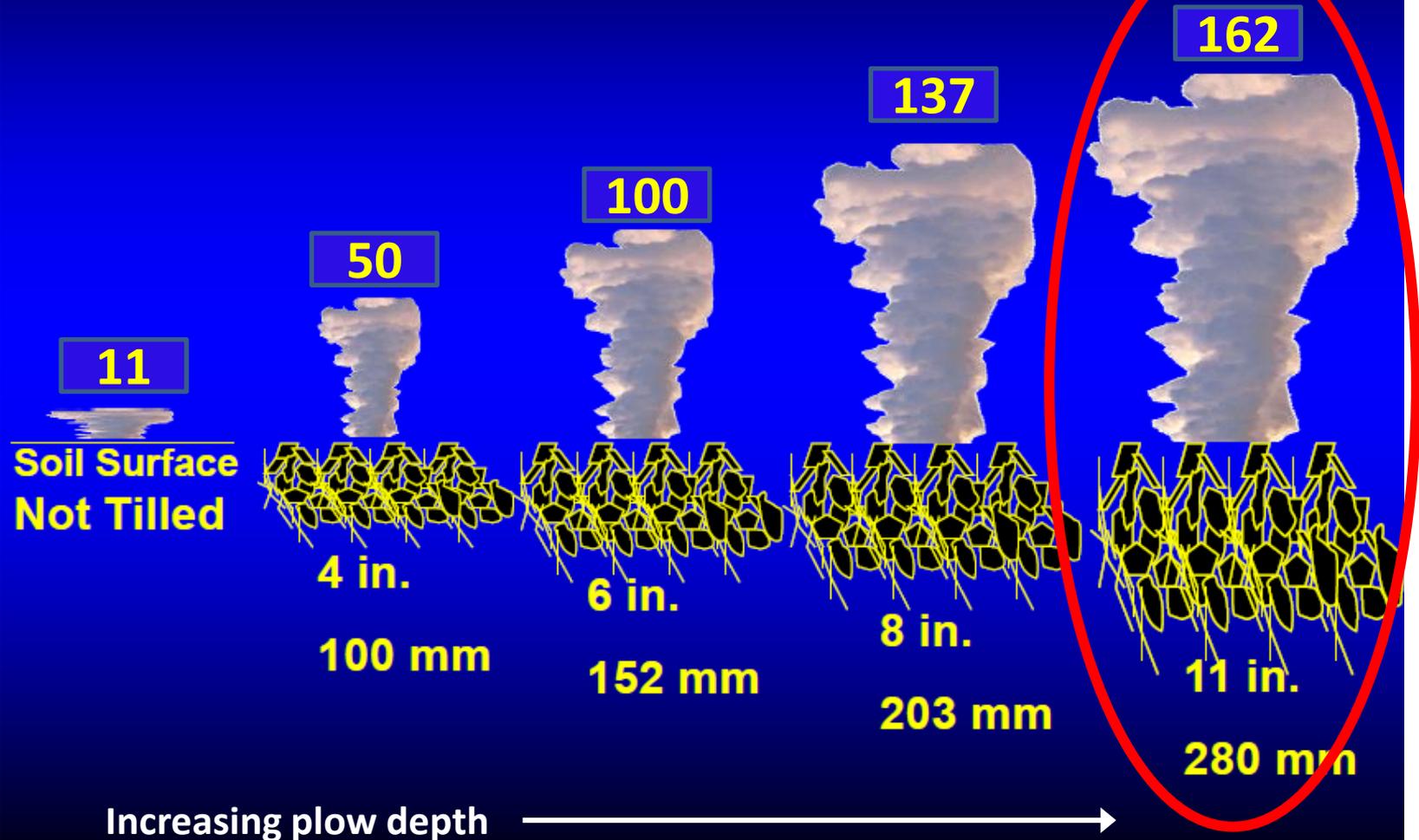


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# Soil health lessons in a minute

by Ray Archuleta, USDA

**Water infiltration test:** shows how healthy soil can infiltrate and capture much more of the rainfall and store it in the soil. This alleviates drought and prevents soil erosion

Permission granted by USDA Natural Resources Conservation Service

[https://www.youtube.com/watch?v=Rpl09XP\\_f-w](https://www.youtube.com/watch?v=Rpl09XP_f-w)

Each soil sample used in the demonstration was air dried

# Soil health lessons in a minute

by Ray Archuleta, USDA

**Soil stability test:** comparison of healthy soil with lots of microbes creating biotic glues and fungal strands that hold the soil together, to soil that has been turned to dirt by repeated plowing.

Permission granted by USDA Natural Resources Conservation Service

[https://www.youtube.com/watch?v=9\\_ItEhCrLoQ](https://www.youtube.com/watch?v=9_ItEhCrLoQ)

Each soil sample used in the demonstration was air dried

# Soil Erosion

**Without the biotic glues and living plant roots, soil is easily washed away by rain or blown away during periods of drought, creating massive dust storms.**

# Dust storm approaching Stratford, Texas 1935.



Back in the 1930's we had no idea how plowing upset the work of soil biology

Credit: NOAA George E. Marsh Album (Public Domain)

<https://commons.wikimedia.org/w/index.php?title=Special%3ASearch&profile=default&search=2015+dust+storm+Colorado&fulltext=Search&uselang=en>

# Dust storm Phoenix 5 July 2011



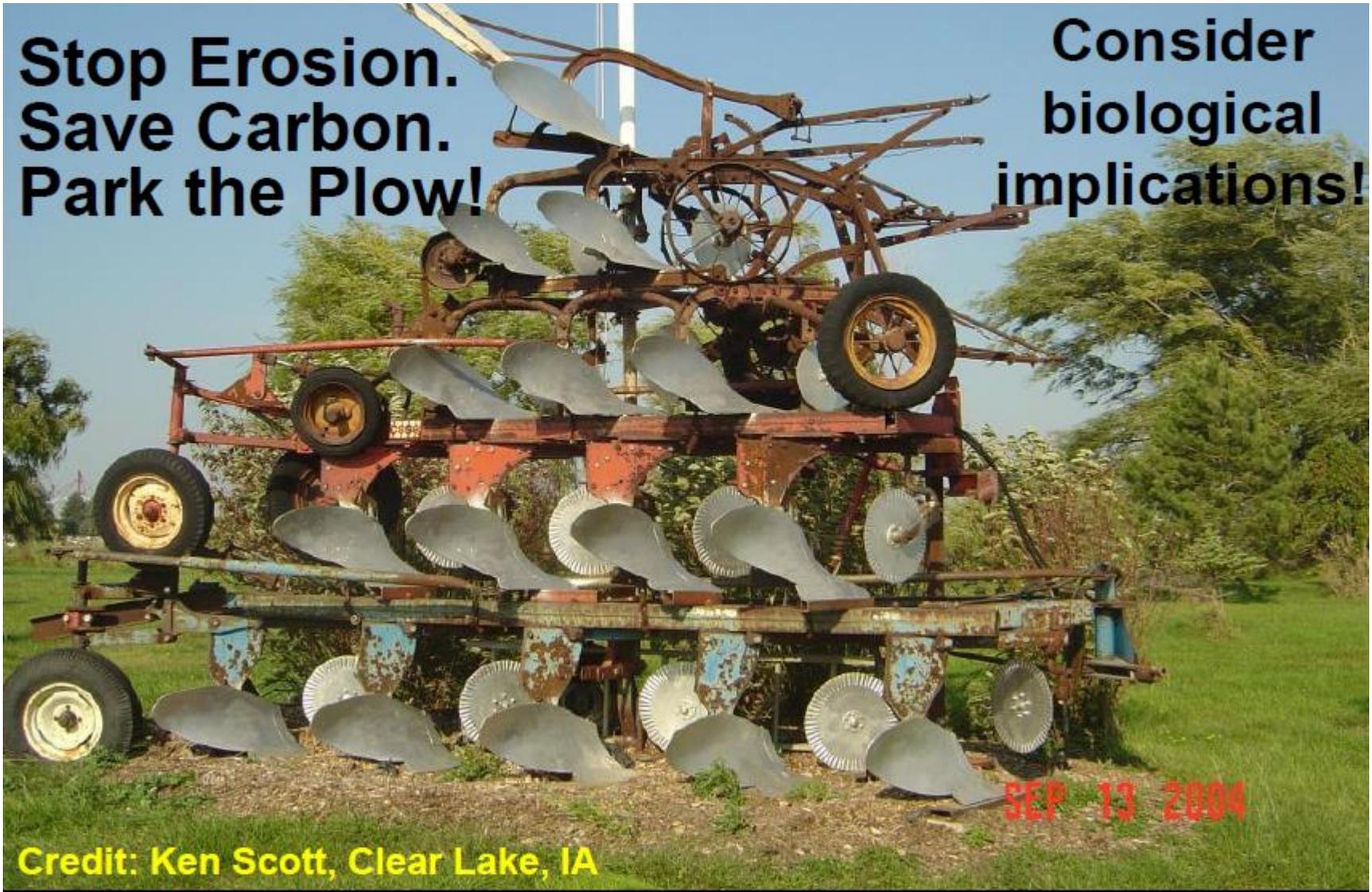
Credit: Roxy Lopez (CC BY – SA 3.0)

<https://commons.wikimedia.org/wiki/File:Duststorm.jpg>

# Time to Retire the Plow

**Stop Erosion.  
Save Carbon.  
Park the Plow!**

**Consider  
biological  
implications!**



**Credit: Ken Scott, Clear Lake, IA**

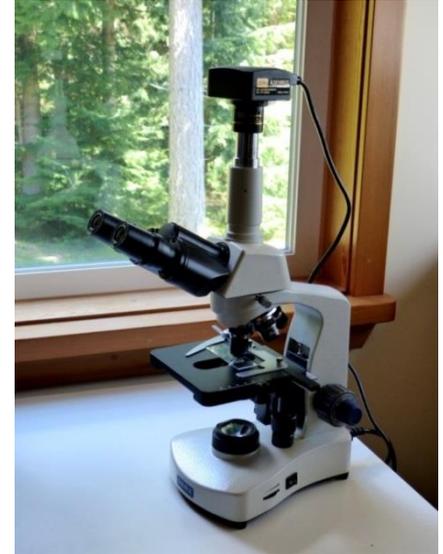
**SEP 13 2004**

# How to rebuild the soil biology?

- By inoculating the dirt with a thin layer of compost or by spraying with a compost extract or compost tea made from the compost.

**It is important to ensure the compost is teeming with a good selection of soil microbes using a soil microscope.**

In Vancouver, Canada, biologically active compost and biological analysis of soil samples are available from <http://www.rootshootsoils.com/>



- Ensure a good cover of plants providing root exudates to feed the microbes.
- Eliminate any existing use of synthetic fertilizers & pesticides over a 3 year period as you rebuild nature's barter system or develop those skills on a portion of your farm or garden.

# Summary of Nature's Barter System

- 1. Plants use photosynthesis to convert carbon dioxide and water into sugars.**
- 2. Plants release up to 40% of the sugars they make through their roots to attract and feed the specific soil microbes they require.**
- 3. For the microbes these root exudates as they are known are like cakes & cookies**
- 4. Bacteria and Fungi recycle dead plant and animal matter, and are able to mine all the additional nutrients plants require from the rocks, sand, silt, & clay, as well as nitrogen from the atmosphere.**
- 5. If it weren't for their microscopic predators these nutrients would remain locked up in the bacteria as these are the foods they need for life. Their microscopic predators need these nutrient but not in such high concentration so they poop out the excess in a plant available form.**
- 6. These microbes also build soil structure which prevents erosion and allow air and water to infiltrate into the soil.**
- 7. Plowing, digging, and the use of synthetic fertilizers and chemicals shuts down nature's barter system and turns living soil into dirt.**
- 8. To transform dirt to soil, inoculate the dirt with a healthy population of indigenous microbes using first class compost and follow Gabe Brown's five principles of Regenerative Agriculture.**

**If you want to learn more check out my YouTube video  
“The Magic of Soil”  
available at:**

<https://www.youtube.com/watch?v=AWILIYSf5ts>

**Phil Gregory’s website with many other presentations**

<https://www.phas.ubc.ca/~gregory/gregory.html>

**END**